Gibsonville Healthy Forest Restoration Project

Plumas National Forest

Feather River Ranger District

Soils Report

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Soil Resource

Introduction

The purpose of the soils effects analysis is to determine the direct, indirect, and cumulative effects of the Gibsonville Healthy Forest Restoration Project on soil, specifically its ability to support plant growth and its soil hydrologic function. The land management activities proposed under this project have the potential to affect the soil resource in a beneficial, indifferent, or adverse manner.

Analysis Framework: Statute, Regulatory Environment, Forest Plan and Other Direction

The Multiple-Use, Sustained Yield Act of 1960

This act states that the National Forests are to be administered for outdoor recreation, range, timber, watershed, wildlife and fish purposes. The Act directs the Secretary of Agriculture to manage these resources in the combination that will best meet the needs of the American people. Sustained yield is defined as achieving and maintaining into perpetuity a high-level periodic output of renewable resources without impairment of the productivity of the land.

National Forest Management Act

The National Forest Management Act (NFMA) of 1976 amended The Forest and Rangeland Renewable Resources Planning Act of 1974. As described in Region 5 FSM 2500 chapter 2550 Supplement (USDA Forest Service 2012) this authority requires the maintenance of productivity of the land and the protection and, where appropriate, the improvement of the quality of soil and water resources. The Act specifies that substantial and permanent impairment of productivity must be avoided.

National Forest Service Manual for Soil Management

Forest Service Manual 2550 (USDA Forest Service 2010) establishes the management framework for sustaining soil quality and hydrologic function while providing goods and services outlined in Forest land and resource management plans. Primary objectives of this framework are to inform mangers of the effects of land management activities on soil quality and to determine if adjustments to activities and practices are necessary to sustain and restore soil quality. Soil quality analysis and monitoring processes are to be used to determine if soil quality conditions and objectives have been achieved.

Forest staff determines soil quality indicators and measures that are appropriate for the proposed activities. Most soil quality indicators are observations and measurements taken at the soil surface and in the upper mineral soil since this region of the soil profile strongly influences soil hydrology and long term soil productivity. Forest staff is directed to estimate the type, amount, and degree of change to soil indicators that the proposed activity may produce by using appropriate analysis methods, scientific literature, past monitoring results, and knowledge of local site and soil characteristics. In most cases, qualitative estimates of the effects of management activities on soils are considered sufficient to meet analysis objectives.

The major objective of soil quality monitoring is to ensure that ecologically sustainable soil management practices are being applied. Soil quality monitoring is to be used to validate and refine management decisions. The focus of project level monitoring is observation and documentation of the implementation of soil protection prescriptions.

Region Five National FSM Supplement for Soil Management

Region 5 FSM 2500 chapter 2550 Supplement (pgs.13-18) establishes soil functions (support for plant growth function, soil hydrologic function, and filtering and buffering function) that the region will use to assess soil conditions (USDA Forest Service 2012). The analysis standards are to be used for areas dedicated to growing vegetation. They are not applied to lands with other dedicated uses, such as system roads and trails or developed campgrounds.

Plumas National Forest Land and Resource Management Plan (LRMP)

Forest Plan standards and guidelines provide the relevant substantive standards to comply with NFMA. Soil management standards and guidelines are not applied to administrative sites or dedicated use areas, such as roads or recreation sites (USDA Forest Service 2010). The 1988 LRMP (USDA Forest Service 1988) establishes standards and guidelines to prevent significant or permanent impairment of soil productivity, including:

- During project activities, minimize excessive loss of fine organic matter and limit soil disturbance according to Erosion Hazard Rating (EHR):
  1. Low to Moderate EHR, conduct normal activities;
  2. High EHR, minimize or modify use of soil disturbing activities;
  3. Very high EHR, severely limit soil-disturbing activities.
- Determine adequate ground cover for disturbed sites during project planning on a case-by-case basis. Suggested levels of minimum effective cover are (these suggested levels have been selected as the ground cover standard for the Gibsonville Healthy Forest Restoration Project):
  1. Low EHR, 40 percent;
  2. Moderate EHR, 50 percent;
  3. High EHR, 60 percent;
  4. Very high EHR, 70 percent.
- To avoid land base productivity loss due to soil compaction, dedicate no more than 15 percent of timber stands to landings and permanent skid trails.

Permanent landings and skid trails do not exist within the project area and the Gibsonville Healthy Forest Restoration Project does not propose such permanent features.

Sierra Nevada Forest Plan Amendment FSEIS and ROD

The 2004 Sierra Nevada Forest Plan Amendment (SNFPA) Final Supplemental Environmental Impact Statement and Record of Decision (USDA Forest Service 2004) amend the Plumas National Forest LRMP but do not add additional standards and guidelines for soil management beyond the standards and guidelines described above for the LRMP.

Effects Analysis

Analysis Methodology

Known Soils Types

Based on the Plumas National Forest Soil Resource Inventory (USDA Forest Service 1989) there are 10 different soil map units identified within the soil effects analysis area Table 1. The PNF Soil Resource Inventory is an Order 3 soil survey that provides general soil map units but does not delineate the exact location of each soil type. The map units typically consist of a group of soils that occupy particular portions of the landscape. A soil map unit is an association or complex of soil components and does not necessarily consist of similar soil types. Map units consist of geographically associated soils that are typically different in soil characteristics and suitability for use and management. Soil textures were determined in proposed treatment units to aid in soil type detection and interpreting expected effects.

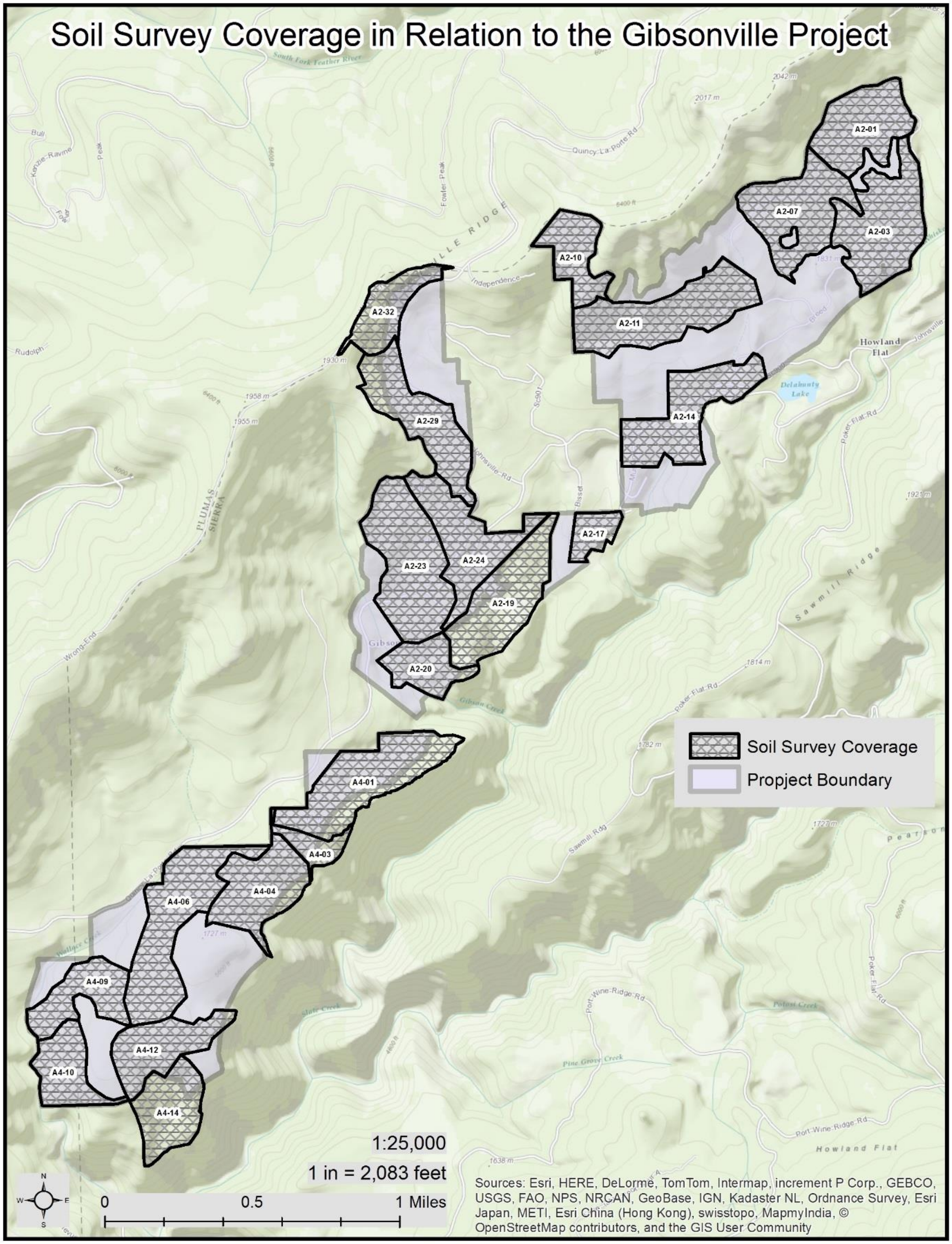
Development of Soil Survey Units

The manner in which the soil survey units were developed was by incorporating 3 components. First, the project looked at the Erosion Hazard Rating (EHR) and reclassified the initial project area from 1 to 3. Second, it looked at past mechanical treatment within the past 25 years and reclassified the project area as either 1, 3 or 4. Third, it looked at percent slope and assigned a value of 1 to areas less than 36 percent and a value of 2 to areas greater than 35 percent. The following step was that all three components were added in manner in which a weighted sum was achieved and reclassified in manner that made it possible to develop the final soil survey units. A map of the soil survey coverage is shown in Figure 1. The maps shows that some of the original soil survey units are outside the proposed project boundary. The reason this occurred is because the project was refined after the surveys were completed. Figure 1 Soil Survey Coverage Map

Table 1 Known soils types within project boundary

Soils Map Unit	Soil Map Unit Name	General Texture of Soil Surface Layer (and depth)	Management Concerns	Acres	Percentage
134	Deadwood-Clallam families	Gravelly loam or very gravelly silt loam or loam (4"), Very gravelly loam (6")	Mass wasting can be a problem.	30.5	3%
151	Dystric Lithic Xerochrepts-Smokey family complex	Cobbly sandy loam (4"), Very gravelly sandy loam (5")	Ground cover maintenance is critical in order to maintain what little soil productivity there is. 50-60% cover should be the minimum standard, with the majority of the material being composed of duff and <3 inch diameter organics.	161.7	13%
180	Gibsonville-Waca families complex	Gravelly loam (8"), Gravelly sandy loam (10")	The soils of this map unit are highly erosive and prone to mass wasting. Ground cover retention and low road density are essential standards that should be applied in this map unit.	130.3	11%
208	Holland, basic-Clallam families complex	Gravelly loam or clay loam (9"), Gravelly loam (6")	Some mass wasting does occur and could pose significant problems for road construction in some areas. Regeneration potential begins to decline rapidly on slopes over 50 percent.	21.5	2%
243	Rock outcrop-Rubble land complex	N/A	Productivity is minimal and access is limited. Equipment operation is extremely difficult and slopes are often in excess of 50 percent.	52.3	4%
265	Smokey family	Very gravelly sandy loam (5")	Some mass instability is evident, primarily along roaded areas and slopes greater than 50 percent.	75.8	6%
277	Trojan family	Loam (11")	It is highly susceptible to deformation (compaction, rutting, etc.), therefore mechanical operations should be curtailed or extremely limited when soils are wet.	122.5	10%
293	Waca-Woodseye families complex	Gravelly sandy loam (10"), Very gravelly loam (10")	Mass instability is common place and a consistent problem on slopes greater than 50 percent. Surface erosion is considerable especially after soil disturbing events. Ground cover maintenance is essential with 40-60% cover (duff and <3 diameter materials) being the standard.	36.1	3%
294	Waca-Woodseye families complex	Same as Soils Map Unit 293	Same as Soils Map Unit 293 just found at greater slopes.	83.4	7%
296	Waca-Woodseye families complex	Same as Soils Map Unit 293	Same as Soils Map Unit 293 just found at greater slopes.	486.3	41%

Figure 1 Soil Survey Coverage Map



Field Data Collection

2013 Soil Surveys

The data collected were sample points along systematic randomized transects, which were designed to sample the geographic and topographic extent and variation of those soil survey units. Transects were randomly located using a topographic map and modified in the field to ensure collection of the necessary information. The data was collected systematically along each transect. Each survey had a minimum of two transects and a total of 30 sample points. Information on slope, soil compaction, soil cover, soil disturbance, soil displacement, and surface erosion were recorded at each sample point with the exception of large down woody material and soil texture. Soil texture was recorded at every 10^{th}point. Wildlife logs were collected were 5^{th} point within a 37 ft. radius that were at least 20 inches in diameter and 10 feet long. Surface erosion was collect at each sample point where within a 37 ft. radius, signs of rilling and gullying were record if they were 20 feet in length or greater. Photos were taken to capture the general condition of the survey area or any potential soil concerns such as rills and gullies.

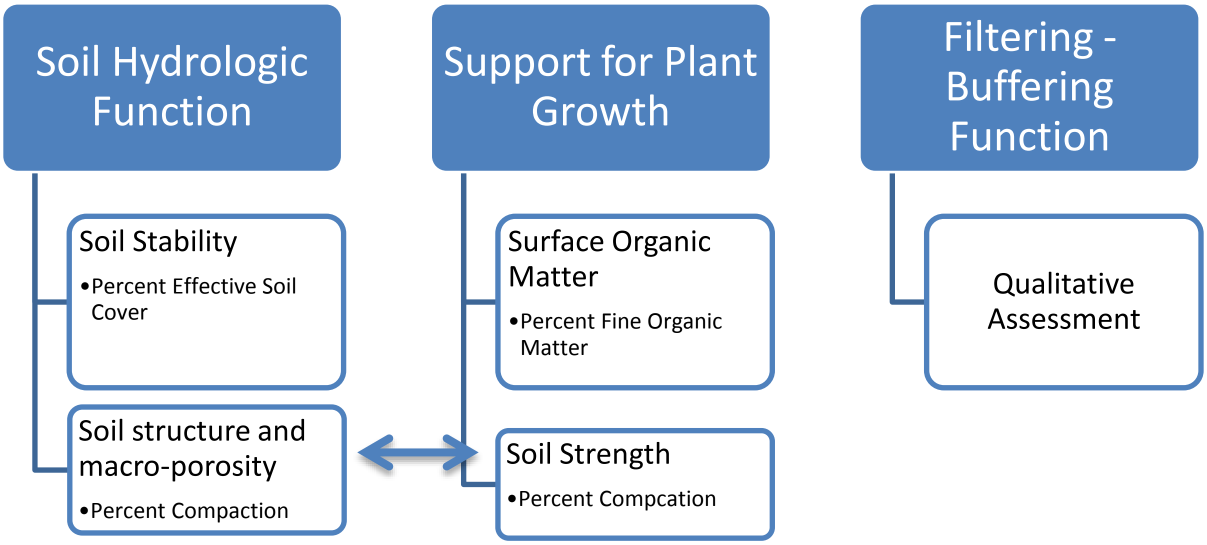
Qualitative Analysis

The soil analysis for this project will be more qualitative than quantitative because no clean crosswalk is possible between the soil survey and project units. The management indicators and measures selected for this project will look at the soil surveys conducted in 2013 to get a general sense of the existing condition. <u>The analysis will identify proposed project units that may affect a soils management measure, standard or guideline</u>

Management Indicators and Measurements

For the proposed project three soil functions were assessed to determine the existing condition and to predict the outcome to those soil functions based on the various management activities proposed. The soil functions that will be assessed are support for plant growth, soil hydrologic function, and filtering-buffering function.

Figure 2 Flow Chart of soil functions in relation to soil indicators and its associated measures



Soil Hydrologic Function and Support for Plant Growth

Soil Structure, Macro-porosity, and Soil Strength

Percent Compaction

Short-term timeframe: 0-5 years

Long-term timeframe: 5-30 years

Data Sources:

- Field Data: Soils surveys were conducted in 2013.
- Annual HFQLG Soil Monitoring Reports.
- The North American long-term soil productivity experiment: Findings from the first decade of research.
- Literature

Spatial Boundary: Proposed treatment units.

Assumptions:

- Platy or massive soil structure indicates compaction.

Methodology:

Each soil survey consisted of 30 sample points and soil compaction was determined at a depth of 4 to 8 inches at every sample point by inserting a spade or shovel into the soil. If the spade was inserted without difficulty the soil was considered to be non-compacted. If the soil was resistant to insertion of spade or shovel, a shovel-full of soil was removed and soil structure examined for indications of compaction (platy or massive soil structure). If the spade could not penetrate the soil down to the depth of 4 to 8 inches after 3 separate times within a square foot of the sample point then the location was considered to be impervious and not susceptible to compaction. These locations were recorded as rock refusal. All the compaction points were added and percent compaction was determined for the surveyed unit.

There is no set standard and guideline for percent compaction but the measure will be utilized in order to get a better understanding of the soil structure, macro-porosity, and soil strength. Timber management activities in particular treatments that involve mechanical equipment have the potential to compact the soil by changing the soil structure and soil porosity. Depending on the degree and aerial extent of compaction it can change the hydrologic function of an area (i.e. unit).

Soil Hydrologic Function

Soil Stability

Percent Effective Soil Cover

Short-term timeframe: 0-2 years after implementation.
Long-term timeframe: 2-10 years after implementation.
Data Sources:

- Field Data: Soils surveys were conducted in 2013.
- Plumas National Forest Soil Resource Inventory and its associated Geographic Information System (GIS) component.
- Annual HFQLG Soil Monitoring Reports.

Spatial Boundary: Proposed treatment units.
Assumptions:

- Duff and litter greater than ½ inch in depth, surface gravels greater than ¾ inch in diameter, woody debris greater than ¼ inch in diameter, and living vegetation count as effective soil cover.
- Units with low EHRs require a minimum of 40 percent effective soil cover under the LRMP but for the this analysis the minimum will be set at 50 percent due to the Region 5 National FSM Supplement for Soil Management indicates that soil cover is 50 percent or greater for desired condition. Units with moderate, high and very high EHRs require a minimum of 50 percent, 60 percent and 70 percent effective soil cover, respectively.

Methodology:
The Plumas National Forest Soil Resource Inventory (USDA Forest Service 1989) and its associated GIS component were used to pre-determine a unit's Erosion Hazard Rating (EHR) for the proposed treatment units that were surveyed. Units with moderate, high, and very high EHR's respectively require a minimum of 50 percent, 60 percent, and 70 percent for effective soil cover to prevent significant or permanent impairment of soil productivity (USDA Forest Service 1988). The EHRs found throughout the project range from moderate to very high but the majority are high. Based on the soil textures collected, the range of soil map units within the proposed surveyed treatment units, and considering that the subwatersheds of the project were rated as moderate based on the HFQLG sensitivity rating factors, the project standard for ground cover for all proposed treatments units will be 60 percent. The analysis will compare the potential changes to effective soil cover throughout the alternatives and address the significance of these changes to soil stability and hydrologic function.

Support for Plant Growth

Surface Organic Matter

Percent Fine Organic Matter on Top of the Mineral Soil

Short-term timeframe: 0-2 years after implementation.
Long-term timeframe: 2-10 years after implementation.
Data Sources:

- Field Data: Soils surveys were conducted in 2013.
- Annual HFQLG Soil Monitoring Reports.
- The North American long-term soil productivity experiment: Findings from the first decade of research.

Spatial Boundary: Proposed treatment units.
Assumptions:

- Duff and litter greater than ½ inch in depth and woody debris between ¼ to 3 inches in diameter will count as fine organic matter on top of the mineral soil.
- Desired condition for fine organic matter on top of the mineral soil is 50 percent or greater and will be rated as good.

Methodology:
The data that was used for the analysis is the same data that was collected for effective soil cover except for woody debris greater than 3 inches, gravels and living vegetation did not count for fine organic matter on top of the mineral soil. If living vegetation was recorded at a sample point then whatever feature (duff and litter, woody debris, surface gravels or bare soil) adjacent to it was recorded. The soils data will be looked at qualitatively to determine if the amount of fine organic matter on top of the mineral soil is adequate for that environment where it's found. For example an area where there is an outcrop or shallow soils you can expect lower site potential class for growing trees and most likely low amounts of fine organic matter. Due to the amount of rain, the type of soil, and geology the desired condition for fine organic matter should be 50 percent or greater. The analysis will compare changes to fine organic matter across alternatives and assess their role to supporting plant growth.

Filtering - Buffering Function

Qualitative Assessment

Short-term timeframe: 0-2 years
Long-term timeframe: 2-10 years
Data Sources: Literature
Spatial Boundary: Proposed treatment units.
Assumptions: N/A
Methodology:
Soil filtering and buffering capacity is the soils ability to protect water quality by immobilizing, degrading or detoxifying chemical compounds or excess nutrients. Soil capacity to buffer and filter chemical compounds and excess nutrients is generally not analyzed in this report because this project does not

involve application of chemicals such as herbicides, pesticides or other amendments. However, the proposed use of borax to prevent the spread of root disease is discussed.

Environmental Consequences

Soil Hydrologic Function and Support for Plant Growth

Soil structure, macro-porosity, and soil strength

Percent Compaction

Alternative A-Direct, Indirect, and Cumulative Effects

The project boundary is approximately 1,200.5 acres and of those 794.5 acres were surveyed for 66 percent survey coverage. Figure 1 shows that the soil survey coverage area goes beyond the Gibsonville project boundary which occurred because of the final refinement of the project. Table 2 displays the existing condition of the soil measures for the project. Eleven out of the twenty-one soil survey units had 0 percent compaction, 7 units had 3 percent compaction, 1 unit had 2 percent compaction, 2 units had 7 percent compaction, and unit A2-19 had 10 percent compaction. The units that have a measureable amount of compaction are a non-issue because the soil porosity will continue to slowly recover to pre-disturbance levels.

Table 2 Existing Soil Condition Measures

Project Soil Survey Unit Number	Percent Effective Soil Cover	Percent Fine Organic Matter	Percent Compaction	Wildlife LWD (Avg. Logs/Acre)	Avg. Slope	Soil Texture
A2-01	90	73	3	30.4	22	(2) Loam, (2) Silty Clay Loam
A2-03	93	70	3	32.1	19	(3) Silty Clay Loam
A2-07	93	83	3	15.2	13	(2) Silt Loam
A2-10	87	87	0	27	33	(2) Silt Loam, Loam
A2-11	97	90	7	20.7	23	Silt Loam, Loam, Clay Loam
A2-14	93	93	0	17.6	23	Silt Loam, (2) Silty Clay Loam
A2-17	93	83	7	1.7	9	(3) Silty Clay Loam
A2-19	83	47	10	0	19	(2) Sandy Loam, Silty Clay Loam
A2-20	100	63	0	0	32	Sandy Clay Loam, (2) Silty Clay Loam
A2-23	87	83	3	8.4	14	Silt Loam, (2) Silty Clay Loam
A2-24	93	83	0	5.1	20	Silt Loam, (2) Silty Clay Loam
A2-29	87	80	0	1.7	35	(2) Silt Loam, Loam
A2-32	53	40	0	0	21	(2) Sandy Loam, Silt Loam
A4-01	100	87	3	15.2	15	(2) Silt Loam, Silty Clay Loam
A4-03	100	93	0	5.1	24	(3) Silt Loam
A4-04	90	87	0	1.7	21	(2) Silt Loam, Silty Clay Loam
A4-06	93	77	0	6.8	29	(3) Silty Clay Loam
A4-09	97	77	3	25.3	28	(3) Silty Clay Loam
A4-10	93	70	3	1.7	50	Loam, (2) Silty Clay Loam
A4-12	100	100	0	0	22	(3) Silt Loam
A4-14	83	73	0	13.5	28	(3) Silty Clay Loam

(number)=the number of times that that soil texture was sampled

Alternative B-Direct and Indirect Effects

Under this alternative 22.8 acres are proposed for aspen release, 359.1 acres as variable density thin (VDT), 115.1 acres as roadside hazard, 181.0 acres as mastication and 477.7 as biomass removal (see Table 3). The total acres of proposed mechanical treatment is 1115.7. These treatments can potentially increase soil compaction. The degree of soil compaction varies with soil texture, moisture content at the time the activity takes place, the weight or ground pressure of the equipment used, and whether woody material remains in place to cushion the weight of the equipment while the operation is occurring. Proposed treatment units are susceptible to compaction when the soil moisture content is near field capacity regardless of the type of soil texture. However, soils with high clay content are a lot more likely to be compacted if operated on by heavy timber equipment when wet (near field capacity) compared to sandy soils and/or soils with high rock content. To further reduce the risk of thinning treatments causing compaction, a Limited Operation Period (LOP) would be applied to the entire project.

Table 3 Maximum acres of treatment across action alternatives

	Acres*	
Treatment Type	**Alt. B**	**Alt. C**
Mechanical Treatment		
Aspen Release	22.8	22.8
Variable Density Thinning (VDT)	359.1	243.3
Roadside Hazard	115.1	115.1
Mastication	181.0	181.0
Biomass Removal	477.7	361.9
Subtotal	***1155.7***	***924.1***
Hand Treatment		
Meadow Restoration	8.9	8.9
Riparian Restoration	15.8	15.8
Hand Cut Pile Burn (HCPB)	596.5	687.1
Subtotal	***621.2***	***711.8***
Underburn (UB)	***891.9***	***866.8***
Total	**2668.8**	**2502.7**

*The values presented are over estimating what will actually be treated because it does not include the RCA buffers, botany, archeology, and other resources stay out areas.

The LOP would allow ground-based harvest equipment to operate only when soils are considered dry. Soil in the 8 inches below the ground surface is defined as "dry" when it is not sufficiently moist to allow a soil sample to be squeezed and hold its shape, or when the squeezed sample crumbles when the hand is tapped. Dryness would be determined by the sale administrator along with the recommendation of district watershed staff. The LOP for soil moisture will also apply to all mastication units. **In variable density thinning, roadside hazard and aspen release units the last 200 feet of main existing skid trials/temporary roads leading to the landings should be subsoiled and any new ones the entire length should be subsoiled**. The depth of the subsoiling will be at minimum depth of 8 inches and a maximum depth of 10 inches where logistically feasible. To minimize the possibility of surface erosion on subsoiled units broken tops and limbs can be collected and scattered along the subsoiled areas where it's logistically feasible.

The 2011 HFQLG Soil Monitoring Report compiled pre- and post-soils data starting in 2001 for the pre-data and 2004 for the post-data. The total number of treatment units complied up to 2011 are 73 thinning and 44 group selection treatment units (Young 2012). The HFQLG Soil Monitoring Reports determined compaction as "'detrimental' when more than 10 percent of the total porosity is lost. The HFQLG soil monitoring determined compaction at the depth of 4 to 8 inches which is similar to how compaction was determined for the proposed units. Soil porosity and compaction monitoring results reported in the 2007 HFQLG Soil Monitoring report stated that a review of monitoring data indicates that legacy compaction is commonplace (Westmoreland et al. 2008). Most of the detrimental compaction observed post-project also existed pre-project (Young 2012). The 2011 report stated that the observed overall changes in detrimental compaction levels were small, averaging 1 percent difference from pre- to post-treatment across units (Young 2012).

The soil structure and macro-porosity in the top 8 inches of mineral soil for most of the stand areas should be similar to the undisturbed, natural condition for the soil type and should provide sufficient infiltration and permeability for the given climate. The low levels of detrimental compaction found during field surveys indicate that this desired condition generally exists throughout the project area. Soil hydrologic function is not expected to be significantly impacted under Alternative B. Visually the soil structure and macro-porosity in the top 8 inches of soil would predominately be unchanged from natural condition for the area of each treatment unit. Localized areas of overland flow and signs of erosion such as pedestals, rills, or gullies are not expected within treatment units. Exceptions could occur along skid trails and landings but erosion on these features would be controlled by implementation of Best Management Practices. The design feature of subsoiling will uncompact the soils and increase the speed in which the soils recover.

The ten year results of The Long Term Soil Productivity (LTSP) study looked at specifically two key components readily affected by management: soil porosity and soil fine organic matter. The LTSP study has 1-acre study plots with 3 levels of compaction (none, intermediate, and severe (similar to a landing)), in factorial combination with 3 levels of fine organic matter removal (bole only, whole tree, whole tree and all forest floor). All plots were clearcut and planted with native species. In addition, to investigate the role of understory vegetation in compaction recovery, vegetation was allowed to naturally return on half of each plot, and controlled on the other half by manual or chemical methods (Powers et al. 2005).

The results indicate that soil compaction effects on total biomass productivity (all vegetation within a site, not just tree growth) differs depending upon the soil particle size or soil texture, along with other factors such as initial bulk density, rock content, and climate. On soils characterized as sandy, compacted plots had greater biomass productivity than uncompacted plots; on soils characterized as loamy, compaction generally resulted in little change in biomass productivity; and on soils characterized as clayey, compaction resulted in up to a 50% reduction in biomass productivity at particular sites, primarily in areas with poor soil drainage or high water table (Powers et al. 2005).

It is important to note that LTSP compaction treatments were experimental; the maximum extent of plot area was compacted (90+ %) and to greater severity than normally encountered during operational practices (a mechanical roller, typically used for compaction of highway subgrades, was used). Therefore, treatments represent a "worst case scenario" when compared with current operational practices. The most disturbing proposed activities proposed such as VDT and aspen release are not near the level of disturbance that was conducted for the LTSP study. The low amount of Forest Service management activities within the project boundary over the past 25 years is a reason why percent soil compaction was found to be so low. Various design features such as the soil moisture LOP (BMP 1.15), reusing existing lands (BMP 1.12) and skid trails will be in place to minimize soil compaction and its potential effect on plant growth productivity. See hydrology and soils appendices for a more robust list of BMPS and design features. All the hand treatment and underburn activities will not affect percent soil compaction. The overall finding is that the implementation of this project will not have a significant negative impact to the soils hydrologic function and its support for plant growth.

Alternative C-Direct and Indirect Effects

Under this alternative 22.8 acres are proposed for aspen release, 243.3 acres as VDT, 115.1 acres as roadside hazard, 181.0 acres as mastication and 361.9 as biomass removal. The total acres of proposed mechanical treatment is 924.1 (see Table 3). There is no change in proposed treatment acres across the two action alternatives for aspen release treatments, roadside hazard and mastication. The main difference between the two action alternatives is that Alternative C both the VDT and biomass removal are no longer treating 231.6 acres. The potential for compaction is lower under this alternative when compared to Alternative B because it's treating 231.6 acres less mechanically. The analysis conducted for this measure under Alternative B applies to this alternative. The implementation of this alternative is not expected to have any direct and/or indirect significant negative effects to compaction nor effect productivity for plant growth and soil hydrologic function.

Alternative B-Cumulative Effects

The construction and use of existing skid trails, landings and temporary roads can compact soils and decrease soil porosity. As discussed above various design features, BMPs, and LOPs will be utilized to mitigate soil compaction (see project file detailed list). In variable density thinning, roadside hazard and aspen release units the last 200 feet of main existing skid trials/temporary roads leading to the landings should be subsoiled and any new ones the entire length should be subsoiled. It is important to note that the SOPs requirements for subsoiling were established from recommendations made by the Regional Soil Scientist as a result of a field review of subsoiling that was conducted June 12-14, 2006 on the Plumas and Tahoe National Forest by personnel from each forest (USDA Forest Service 2006c). Cumulative effects related to soil porosity and compaction as a result of actions associated with this alternative will be mitigated through subsoiling of compacted soils along with the implementation of other soil protection measures and mitigations. The implementation of this project will not have a significant negative impact to the soils hydrologic function and its support for plant growth.

Alternative C-Cumulative Effects

Although less acres are potential treated in this alternative the same conclusion discussed in Alternative B applies to this alternative.

Soil Hydrologic Function

Soil Stability

Percent Effective Soil Cover

Alternative A-Direct, Indirect, and Cumulative Effects

The data presented here only represents the surveyed units. The range of effective soil cover is 53 percent to 100 percent and the average is 91 percent. For exact percentages of effective soil cover by soil survey unit see Table 2. Under the existing condition all of the surveyed units meet the project's 60 percent minimum coverage for effective soil cover except for soil survey unit A2-32 at 53 percent (Table 2). In fact all the units surveyed have a percent effective soil cover of 83 percent or greater except for unit A2-32. Although unit A2-32 does not meet the project standard for percent effective soil cover it does meet the Region 5 National FSM Supplement for Soil Management minimum for effective soil cover of 50 percent. Figure 3 shows what the conditions are on the ground for unit A2-32 at 2 transect points. The figure shows no evidence of erosion and the field data sheet does not mention anything about any erosional features. The units that were not surveyed have a high probability that they meet the project standard for percent effective soil cover because the soil surveys covered 66 percent of the project boundary and the survey results show that the landscape does meet the project standard for effective soil cover.

Figure 3 Effective soil cover of unit A2-32

Alternative B-Direct and Indirect Effects

Direct and indirect effects on this measure include partial removal of effective soil cover. Ground disturbance associated with the proposed activities (aspen release, VDT, roadside hazard, biomass removal, burning of hand-cut trees, and prescribed underburning treatments) of Alternative B are expected to temporarily reduce effective soil cover from the existing condition. While it is difficult to predict precise treatment effects on forest floor materials, general trends are well established.

The 2011 HFQLG Soil Monitoring Report presents the effects of this measure for over 100 units treated on the 3 National Forests that were implementing the HFQLG pilot project, including units on Plumas National Forest. Pre-treatment data collection started in 2001 and post-treatment data collection began in 2004. The total number of treatment units complied up to 2011 is 73 thinning units. According to the report, thinning unit's averaged 90 percent effective soil cover pre-activity and 83 percent post-activity (Young 2012).

The HFQLG Soil Monitoring Reports demonstrate that mechanical thinning treatments such as those proposed under Alternative B are likely to cause reductions in the areal extent of effective soil cover, with losses averaging 7 percent for thinned units and group selection units being more prone to losses of soil cover (Young 2012). Group selections are not being proposed in any of the alternatives but they do represent the most disturbing timber management activity to soils according to the HFQLG Soil Monitoring Report data. Even though group selection treatments were the most disturbing to soils, the average percent effective soil cover post-treatment was 66 percent which is within the range of minimum required effective soil cover (Young 2012). The proposed aspen release treatments are the closet treatments similar to group selections but are still not as disturbing to soils. These treatments are expect to meet effect soil cover post-implementation. Roadside hazard and biomass removal are less disturbing to the effective soil cover than VDT because less trees are removed which results in a smaller logging system footprint (landings, skid trails, and temporary roads). Logging systems are a large component in the reduction in effective soil cover. Due to the 91 percent average for effective soil cover and the minimal expected loss of effective soil cover due to thinning it's expected that all surveyed and all if not the majority of non-surveyed units will meet the standard (minimum) for effective soil cover. The only exception is Gibsonville treatment unit 571 which is associated with soil survey unit A2-32 with 53 percent effective soil cover.

Unit 571 is proposed to be masticated or have biomass removed and underburned it's expected that mastication will increase in effective soil cover due to the nature of the fuels treatment activity. The masticator equipment rearranges the ladder fuel (shrubs and small conifers) to the ground as chopped up organic matter. If the unit is well above 60 percent for effective soil cover than underburning can proceed. **Due to the nature of biomass removal which does reduce effective soil cover as a mitigation the option to treat unit 571 as biomass will not proceed.**

The use of BMPs and design features is expected to result in sufficient soil cover. However, if a unit does not have adequate effective soil cover post-treatment then certified weed-free straw would be scattered on bare soil areas until the project standard for effective soil cover is met. If straw is applied, the minimum thickness will have to be 0.5 inches to count as effective soil cover. With soil cover expected to meet the project standard of 60 percent, soil hydrologic function would be protected and accelerated erosion would be prevented.

Mastication units are anticipated to see increases in effective soil cover as mentioned earlier, it rearranges the ladder fuels to the ground as chopped up organic matter. Pile burning and underburning could reduce effective soil cover. Pile burning would remove forest floor at a relatively small scale compared with the area affected by mechanical traffic. Meadow and riparian restoration treatments are hand treatments that fell trees up to 16 inches in diameter breast height (DBH) and piles the material to be burned at later time. The hand felling of trees does not reduce soil cover and the burning of the piles as mentioned above only reduces the soil cover at pile locations which is insignificant. In the majority of the proposed underburning treatment units, treatments are expected to occur under prescribed conditions that would not result in complete combustion of the duff and litter layers. Instead it will burn in a mosaic pattern only consuming the fine organic matter where the fire went through. Pile burning and underburning of the proposed treatments would occur within 3 years as a follow-up treatment or as a standalone treatment. The underburning within the RCA buffers would have a mosaic pattern due to the varying moisture conditions and the impacts should be minimal and not significant to effective soil cover.

BMP monitoring of the Upper Slate DFPZ project occurred in 2006 in underburn treatment units where the fuel moisture was too dry, resulting in moderate to high intensity fire. During these treatments some areas had little to no consumption of the duff and litter while other areas had complete consumption that result in exposed bare soil, causing rilling and erosion of the surface soils (USDA Forest Service 2006a). However, these effects were not widespread and were not observed to cause significant soil erosion. BMP evaluations were performed in 12 prescribed fire units on the Upper Slate DFPZ project, with 2 units rating as deficient for BMP implementation. To prevent a high intensity fire in proposed treatment units of the Gibsonville Healthy Forest Restoration Project, burning would occur during cool conditions to prevent loss of effective soil cover below standards and guides. The BMP effectiveness was rated as 92 percent for underburn units for 2011 (USDA Forest Service 2011).

A significant reduction in effective soil cover would increase the risk of surface soil erosion temporarily in affected areas. While the overall percentage of effective soil cover for a unit is a very good measure for analyzing soil productivity effects and soil hydrologic function, actual soil erosion realized would be highly dependent upon the size and distribution of bare areas as well as site specific factors such as soil erodibility and slope. The effect of short term reductions in soil cover for Alternative B would generally be well distributed across thinning units. Concentrated removal of soil cover is most likely to occur in areas such as landings, skid roads, temporary roads, and equipment tracks. Soil erosion would be minimized by the installation of erosion control structures such as cross ditches and waterbars. The 2011 Best Management Practices Evaluation Program (BMPEP) Report found that the implementation and effectiveness of the BMPs for 2011 was at 100 percent and 97 percent, respectively.

Mechanical cutting and yarding of trees results in substantial breakage of tops and limbs that can be left on the ground to maintain soil cover. Throughout much of the mechanically-treated area, traffic would mostly occur with low ground pressure equipment that typically make only one or two passes over a given section of ground, and would generally leave enough live grass and shrub components to retain effective soil cover. Multiple passes by rubber-tired equipment on skid trails would remove most of the live vegetation components of soil cover on those areas. However, those areas are relatively small compared with the rest of the treated stand and BMPs can effectively prevent substantial erosion of skid trails and landing, allowing them to eventually re-vegetate.

The implementation of the project would not cause any significant negative effects to soil productivity for plant growth and soil hydrologic function due to lack of soil cover because of the initial condition (pre-treatment/existing) containing a high percentage of effective soil cover in conjunction with design features and BMPs. An adequate level of well-distributed soil cover is expected in all treated units and signs of erosion would not be visible or would be very limited in degree and extent.

Alternative C-Direct and Indirect Effects

Direct and indirect effects on this measure include partial removal of effective soil cover. Ground disturbance associated with the proposed activities (aspen release, VDT, roadside hazard, biomass removal, burning of hand-cut trees, and prescribed underburning treatments) of Alternative C is expected to temporarily reduce effective soil cover from the existing condition. The analysis done under Alternative B for this measure also applies to Alternative C. The discussion on unit 571 in Alternative B applies to this alternative because the same treatments are proposed. **Therefore no biomass removal should occur in unit 571 and underburning can only occur if the unit is masticated first.** All proposed treatment units are expected to meet the project standard for effective soil cover due to overall high percentage of effective soil cover, LOPs, BMPs, and design features. The implementation of the project would not cause any significant negative effects to soil productivity for plant growth and soil hydrologic.

Alternative B-Cumulative Effects

The implementation of this alternative has important positive cumulative effects for long term soil productivity, which is the reduction of future wildfire risk or a modification of future wildfire behavior and intensity. A high intensity wildfire, occurring under conditions of high heat and low humidity, would result in nearly complete combustion of soil cover, and a significant increase in the risk of erosion. The proposed treatments are designed to reduce the risk of wildfire and behavior of a wildfire by modifying the arrangement of fuels and by regenerating disease free and fire-resilient species.

Alternative C-Cumulative Effects

Although less acres are potential treated in this alternative the same conclusion discussed in Alternative B applies to this alternative.

Support for Plant Growth

Surface Organic Matter

Percent Fine Organic Matter on Top of the Mineral Soil

Alternative A-Direct, Indirect, and Cumulative Effects

The data presented here only represents the surveyed soil units. The range of percent fine organic matter on top of the mineral soil is 40 percent to 100 percent and the average is 78 percent. For exact percentages of percent fine organic matter on top of the mineral soil by soil survey unit see Table 2. The desired condition for percent fine organic matter on top of the mineral soil is 50 percent or greater. All but 2 (A2-19 & A2-32) of the soil survey units meet the desired condition.

Figure 4 Fine organic matter on top of the mineral soil of unit A2-19.

Figure 4 shows a snapshot of how the landscape looks like in soil survey unit A2-19 which was found to have a 47 percent fine organic matter. The unit had low fine organic matter because landscape is full of mine tailings which has limited the accumulation of fine organic matter. Eighty-five percent of soil survey unit A2-19 is outside of the proposed Gibsonville units and is not a true presentation of unit 608. Soil survey unit A2-19 only covers 15 percent of proposed Gibsonville proposed project unit 608 and the rest of the unit is covered by soil survey unit A2-23 at 18 percent and A2-24 at 67 percent. Both A2-23 and A2-24 have 83 percent fine organic matter on top of the mineral soil. The weighted sum for percent fine organic matter for proposed unit 608 is 77 percent which meets the desired condition.

The other soil survey unit that did not meet the desired condition of 50 percent or greater for fine organic matter on top of the mineral soil is unit A2-32 at 40 percent. Figure 3 shows a snapshot of how the landscape looks like for unit A2-32. The 2 photos show 2 distinct stands/landscapes one that is much more open with less fine organic matter and the other with more fine organic matter. Soil survey unit A2-32, the existing condition numbers will be associated with proposed unit 571. Under the no-action alternative, the existing condition for fine organic matter on top of the mineral soil would remain same.

There is a slight possibility that there may be some units that may not meet the desired condition of 50 percent or greater of fine organic matter in the units that were not surveyed. The rate of fine organic matter accumulation is unknown therefore the timeframe for those units that may not meet the desired condition is also unknown. If a high intensity wildfire occurred, the fine organic matter would be burned (combusted) and alter decomposition rates and nutrient cycling processes that are essential for plant growth and soil organisms. When fine organic matter burns, essential nutrient loss can occur during a fire due to nutrient transfer to the atmosphere through volatilization and ash convection or due to surface runoff (erosion) of deposited nutrients in the surface ash layer (Neary et al.2005, Rasison et al. 1985). Nutrients at a greater depth in the soil profile may be immediately lost following a fire due to leaching (Boerner 1982; Neary et al. 2005). Soil temperatures may be elevated for months or years depending on the degree of fine organic matter consumption (Neary et al. 1999). Such changes in the soil temperature regime would affect the rates of biological activity in the soil, resulting in altered nutrient cycling regimes (Neary et al. 2005). These effects could adversely affect long term soil productivity for plant growth.

Alternative B-Direct and Indirect Effects

Direct and indirect effects on this measure include the removal of soil fine organic matter, potential short-term reduction of soil nutrients, and loss of habitat for organisms inhabiting soil fine organic matter. To protect soil productivity for plant growth, surface fine organic matter should be maintained in the amounts sufficient to sustain soil microorganisms and provide for nutrient cycling.

The Long Term Soil Productivity (LTSP) study is a national and international study initiated in 1989 comprised of 62 study sites, including sites in the Sierra Nevada (Powers et al. 2005). The goals of the study are to gain understanding of potential soil productivity and effects of land management activities across a variety of sites. The national ten year results indicate that bole only and whole tree fine organic matter removals, similar to the thinning treatments proposed for this project, have had no detectable effects on soil nutrition or biomass productivity. Significant reductions in soil carbon and nutrient availability were observed only for the extreme case of whole tree removal plus complete removal of all surface fine organic matter on the forest floor. However, the data trend indicated no general decline in biomass productivity across any of the fine organic matter removal levels. Given the modest and short-term reductions of fine organic matter that are expected due to the proposed treatments, those reductions would not significantly change the soil production potential for plant growth within the proposed units.

The precise reduction of fine organic matter is difficult to predict but trends would likely be consistent with those observed for effective soil cover in the HFQLG soil monitoring reports as described above. A reason for similar expected trends between the two measures is because both count duff and litter, and woody debris as components for those measures. The only differences is that effective soil cover counts surface gravels, live vegetation, and woody debris greater than 0.25 inches in diameter (fine organic matter is only from 0.25 to 3 inches in diameter). For example the 2011 HFGQL Soil Monitoring Report presented an average difference between the pre-and post-treatment of 73 thinning units of 7 percent for effective soil cover (Young 2012). If the assumption is made that a reduction in effective soil cover only occurred to duff and lifer, and woody debris then the results could be applicable to fine organic matter. This assumption present a worst case scenario and is over estimating the loss of fine organic matter. The observed trends for thinning treatments identified in the 2011 HFQLG Soil Monitoring Report will apply to the variable density thinning treatments proposed for this project.

Aspen release treatments are expected to be more similar to group selection treatments than thinning treatments. Making the same assumptions made above the reduction in effective soil cover trend represents a worst case scenario in expected reduction in fine organic matter. The 2011 HFQLG Soil Monitoring Report found that the average effective soil cover for 44 group selection units pre-activity was 83 percent and 66 percent post-activity (Young 2012). The fine organic matter for 3 of the 4 aspen release treatment units ranges from 70 percent (A2-03) to 83 percent (A2-07). Aspen treatment unit A4 not surveyed. If the desired condition is not reached post-implementation then short-term the fine organic matter would be considered to be fair condition but long term it would be in good condition because the enhancement of the aspen habitat brings a more diverse plant community and recruitment of fine organic matter.

As discussed in the no action alternative for this measure, soil survey unit A2-19 has 47 percent fine organic matter on top of the mineral soil but the only unit that was identified for potentially not meeting the desired condition is proposed unit 608. The weighted average percent fine organic matter for unit 608 was determined to be 77 percent therefore unit 608 does meet the desired condition. Unit 608 is proposed for VDT, biomass removal, and underburn. Post-implementation it is expected that the percent fine organic matter would be at desired condition.

Proposed unit 571 is proposed to be mastication or have biomass removed and underburned. As a design feature unit 571 will not have biomass removal done because it does not meet the effective soil cover standard as discussed in the effective soil cover measure under Alternative B. Since the only treatment that can occur now is mastication and underburn the desired condition for fine organic matter would be achieve immediately after being masticated. The underburn would occur under ideal conditions that would result in a low intensity prescribed fire which will reduce fine organic matter but the exact amount is hard to determine. The end result is that the treatments in unit 571 is expected to improve fine organic matter compared to the existing condition.

Hand cut pile burn will have less of an impact on the percent fine organic matter than mechanical thinning therefore not impact the soils ability to support plant growth and its soil hydrologic function. Mastication treatment units may see an increase in percent fine organic matter due to the nature of the treatment where the masticator shreds small trees and shrubs therefore increasing the area of fine organic matter on top of the mineral soil. Underburn treatment units will see a reduction in fine organic matter but the extent of the reduction is hard to predict. Under the right conditions a low intensity underburn should not reduce the soils ability to support plant growth and soil hydrologic function. However, even if the desired condition for organic matter cannot be achieved, it still will not significantly change the soil biomass productivity potential as indicated in the LTSP study.

Alternative C-Direct and Indirect Effects

Of the mechanical treatments the most disturbing to fine organic matter in descending order are aspen release, VDT, roadside hazard and biomass removal fallowed by underburn. There is no difference in proposed treatment acres for aspen release and roadside hazard across both action alternatives (see Table 3). Alternative C proposes 115.8 acres less of VDT and biomass removal when compared to Alternative B. Alternative C proposes 25.1 acres less of underburn treatment than Alternative B. This alternative proposes a total of 687.1 acres of HCPB which is 90.6 acres more than what was proposed in Alternative B. There is no difference in the amount of acres treated between the action alternatives for mastication, meadow restoration, and riparian restoration. Overall, there are 231.6 acres less of mechanical treatment for Alternative C which means a lower reduction in fine organic matter is expected.

The implementation of this alternative is not expected to reduce the fine organic matter on top of the mineral soil below the desired condition for the areas that were surveyed. It’s expected that the areas that weren’t surveyed are likely to meet the desired condition because 66 percent of the project was surveyed and the average fine organic matter was found to be 78 percent. The analysis discussed in Alternative B applies to this alternative as well. The implementation of the project would not cause any significant negative effects to soil productivity for plant growth.

Alternative B-Cumulative Effects

As discussed in the direct and indirect effects across the action alternatives the most disturbing management activities to fine organic matter in descending order are aspen release, VDT, roadside hazard and biomass removal fallowed by underburn. These activities would be the candidates that are more likely to affect cumulative fine organic matter and the soils ability to support plant growth. Overall, the cumulative effects of the proposed activities, when considered with the past, present, and future activities, are expected to result in fine organic matter conditions that meet the project-defined desired condition of 50 percent. Increases in woody materials on the forest floor via mastication may cause short term changes in decomposition and carbon and nutrient dynamics in affected areas. Micro-organisms that decompose wood would immobilize nitrogen and other nutrients while decaying the woody material. As the wood decomposes, those nutrients would be released and made available to plants and other organisms (Swift 1977). It is not expected that the implementation of this alternative would result in detrimental cumulative effects to the water-holding capacity, nutrient retention, and habitat for soil-micro-organisms that are fundamental to maintaining the support for plant growth.

Alternative C-Cumulative Effects

Although less acres are potential treated in this alternative the same conclusion discussed in Alternative B applies to this alternative.

Filtering - Buffering Function

Qualitative Assessment

Assessment of Borax

Alternative A-Direct, Indirect, and Cumulative Effects

Under the no-action alternative, the application of borax the active ingredient in Sporax a fungicide would not be used. The no-action alternative will not change the effective soil cover, surface organic matter, soil organic matter, and the extent of detrimental compaction which are all components that contribute to soils ability to filter and buffer chemical compounds.

Alternative B-Direct, Indirect and Cumulative Effects

To prevent the spread of Heterobasidion annosum (annosus) root disease approximately 182.3 acres (see Appendix E of the Silviculture Report) sodium tetraborate decahydrate (a fungicide treatment) is proposed to be used under this alternative. Sodium tetraborate decahydrate, also known as borax, is the active ingredient and sole constituent in Sporax. The compound borax is not applied as a liquid using backpack, broadcast or aerial spray methods and it is not applied directly to vegetation (USDA Forest Service 2006b). Borax is applied to freshly-cut stump surfaces and is typically applied at a rate of one pound per 50 square feet of stump surface. This is equivalent to one pound of borax on 60 twelve-inch stumps (Sporax label, Wilbur-Ellis Company).

It is presently unknown if any fungicide containing borax has recently been applied on private land within the project soil effects analysis area. Boron is the agent of toxicological concern from Sporax and occurs naturally in soil (USDA Forest Service 2006b). According to the Human Health and Ecological Rick Assessment for Borax Final Report the effects of Sporax to soil microorganisms essential for formation of soil organic matter have not been characterized, and there is a risk of environmental exposures affecting nontarget microorganism (USDA Forest Service 2006b). However, given the atypical application method for Sporax, widespread exposures are not likely, and the risk of effects to soil indicators is minimal. The use of borax will have no significant direct, indirect, and cumulative effects to the soils ability to filter and buffer any chemical compounds.

Alternative C- Direct, Indirect and Cumulative Effects

To prevent the spread of Heterobasidion annosum (annosus) root disease approximately 182.3 acres of borax is proposed to be used in this alternative. The affects analysis conducted under Alternative B applies to this alternative.

Forest Plan Consistency

Alternatives B and C would be in compliance with Forest Plan Standards and Guidelines and other regulations pertinent to the Soil Resource.

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